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TECHNICAL COMMUNICATIONS IN AEROSPACE: AN ANALYSIS OF THE PRACTICES REPORTED BV U.S. AND EUROPEAN AEROSPACE ENGINEERS AND SCIENTISTS

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National Aeronautics and Space Adminstration
Langley Research Center

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Two pilot studies were conducted that investigated the technical communications practices of U.S. and European aerospace engineers and scientists. Both studies had the same five objectives: (1) solicit opinions regarding the importance of technical communications; (2) determine the use and production of technical communications; (3) seek views about the appropriate content of an undergraduate course in technical communications; (4) determine use of libraries, information centers, and online databases; (5) determine use and importance of computer and information technology to them. A self-administered questionnaire was mailed to randomly selected aerospace engineers and scientists, with a slightly modified version sent to European colleagues. Their responses to selected questions are presented in this paper.

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ABSTRACT

As part of Phases 1 and 4 of the **NASA/DOD Aerospace Knowledge Diffusion Research Project**, two pilot studies were conducted that investigated the technical communications practices of U.S. and European aerospace engineers and scientists. Both studies had the same five objectives: first, to solicit the opinions of aerospace engineers and scientists regarding the importance of technical communications to their profession; second, to determine the use and production of technical communications by aerospace engineers and scientists; third, to seek their views about the appropriate content of an undergraduate course in technical communications; fourth, to determine aerospace engineers' and scientists' use of libraries, technical information centers, and on-line databases; and fifth, to determine the use and importance of computer and information technology to them. A self-administered questionnaire was mailed to randomly selected aerospace engineers and scientists who are members of the American Institute of Aeronautics and Astronautics (AIAA). A slightly modified version was sent to a group of European aerospace engineers and scientists in the NATO AGARD (Advisory Group for Aerospace Research and Development) countries. Responses of the U.S. and European aerospace engineers and scientists to selected questions are presented in this paper.

INTRODUCTION

The **NASA/DOD Aerospace Knowledge Diffusion Research Project** is a cooperative effort that is sponsored by NASA, Office of Aeronautics, Exploration and Technology (OAET) and the DOD, Office of the Assistant Secretary of the Air Force, Deputy for Scientific and Technical Information. The research project is a joint effort of the Indiana University, Center for Survey Research and the NASA Langley Research Center. This 4-phase project will provide descriptive and analytical data regarding the flow of scientific and technical information (STI) at the individual, organizational, national, and international levels. Phases 1 and 4 examine the communications habits and practices of the U.S. and European aerospace engineers and scientists respectively. The project focuses on both the channels used to communicate information and the social system of the aerospace knowledge diffusion process. The results of this research will provide useful information to R&D managers, information managers, and others concerned with improving access to and utilization of aerospace STI.

Methodology

To develop and refine appropriate survey instruments and techniques, two pilot studies were conducted to validate questions for use in the large scale studies. Members of the American Institute of Aeronautics and Astronautics (AIAA) comprised the study population for the Phase 1 pilot study. From a random sample of 2,000 U.S. participants, 606 provided usable questionnaires (30.3% response rate) were received by the established cut off date. The results of this study are presented in NASA Technical Memorandum 101534 (1). A list of approximately 250 non-U.S. aerospace engineers and scientists working in the fields of cryogenics, magnetic suspension, and adaptive walls served as the sample frame for the Phase 4 pilot study. Aerospace engineers and scientists in non-NATO nations were eliminated. Two questionnaires were sent to 125 of the remaining members of the sample frame; each person was asked to give one to a colleague. Sixty seven questionnaires (26.1% response rate) were returned by the established cut off date. The results of both pilot studies are highlighted in this paper.

Demographic Information About the Survey Respondents

Survey respondents were asked to provide information regarding their professional duties, type of organization, years of professional work experience, whether English was their first (native) language, and their gender. These demographic findings follow (numbers given are percentages).

	U.S.	European
Professional Duties		
Design/development	38%	12%
Admin./management	24	9
Research	20	52
Other	12	27
Organizational Affiliation		
Industry	62	17
Government	28	23
Academia	7	55
Other	3	5
Professional Work Experience		
10 years or less	35	25
10 19 years	19	30
20 29 years	23	27
30 years or more	22	18
Education		
Bachelor's degree or less	33	17
More than a Bachelor's degree	67	83
Training		
Engineer	90	75
Scientist	10	25
English First (native) Language	94	40
Gender		
Male	95	95
Female	5	5

A comparison of the two groups reveals more differences than similarities. The two groups differ significantly in professional duties, organizational affiliation and education; they are similar in years of professional work experience and gender. However, demographic differences may be due to the lack of non-probability sampling for the European group.

Importance of Technical Communications

Approximately 90% of the U.S. respondents and 97% of the European respondents indicated that the ability to communicate technical information effectively is very important. U.S. aerospace engineers and scientists spend an average of 13.95 hours per week communicating technical information to others; Europeans spend an average of 11.04 hours per week. U.S. aerospace engineers and scientists spend an average of 12.57 hours per week working with technical communications received from others, and European aerospace engineers and scientists spend 12.08 hours per week. Considering both the time spent producing information and using information received from others, technical communications takes up approximately 66% of the American aerospace engineer's and scientist's 40-hour work week and 58% of the European aerospace engineer's and scientist's work week. Approximately 72% of the U.S. respondents and 59% of the European respondents indicated that as they have advanced professionally, the amount of time they spend communicating technical information to others has increased. Likewise, 61% of the U.S. and 67% of the Europeans indicated that as they have advanced professionally, the amount of time they spend working with technical communications received from others has increased.

The Production and Use of Technical Communications

Memos, letters, and audio visual (A/V) materials are the technical information products most frequently produced by U.S. and European aerospace engineers and scientists. On the average, Americans produced 29 memos, 22 letters, and 7 A/V materials in a 6-month period. Europeans produced 76 letters, 58 memos, and 27 A/V materials. Trade/promotional literature, press releases, and technical manuals are the technical information products least produced by U.S. aerospace engineers and scientists. AGARD technical reports, technical proposals, and trade/promotional literature are the technical information products least produced by the Europeans. Americans use various sources of help when preparing written technical information products: 50% consult colleagues, 47% utilize the services of a graphics department, and 6% work with writer/editors. Europeans also seek help from various sources: 72% consult colleagues, 30% utilize the services of a graphics department, and 12% work with writer/editors.

Memos, letters, and drawings/specifications are the technical information products most frequently used by U.S. aerospace engineers and scientists. On the average, they used 24 memos, 17 letters, and 8 drawings/specifications during a 1-month period. Proposals, technical manuals, and computer program documentation are the technical information products least used by U.S. aerospace engineers and scientists during a 1-month period. Letters, memos, and journal articles are the technical information products most frequently used by European aerospace engineers and scientists. On the average, they used 14 letters, 14 memos, and 10 journal articles during a 1-month period. Computer program documentation, AGARD technical reports, and U.S. government technical reports are the technical information products least used by European aerospace engineers and scientists during a 1-month period.

The kinds of technical information most frequently produced by U.S. aerospace engineers and scientists include basic scientific and technical information, in-house technical data, technical specifications, products and performance characteristics, and computer programs. The least frequently produced kinds of technical information include government rules and regulations, patents, codes of standards and practices, economic information, and experimental techniques. On the other hand, basic scientific and technical information, in-house technical data, computer programs, technical specifications, and product and performance characteristics are the kinds of technical information

most frequently used by U.S. aerospace engineers and scientists. Patents, economic information, codes of standards and practices, design procedures and methods, and experimental techniques were the kinds of technical information least frequently used.

The kinds of technical information most frequently produced by European aerospace engineers and scientists include basic scientific and technical information, in-house technical data, experimental techniques, technical specifications, and computer programs. The least frequently produced kinds of technical information include government rules and regulations, codes of standards and practices, patents, economic information, and design procedures and methods. On the other hand, basic scientific and technical information, in-house technical data, experimental techniques, technical specifications, and product and computer programs are the kinds of technical information most frequently used by European aerospace engineers and scientists. Patents, codes of standards and practices, economic information, design procedures and methods, and government rules and regulations are the kinds of technical information least frequently used by European aerospace engineers and scientists.

In addition to personal knowledge, on which they rely **first**, aerospace engineers and scientists use a variety of information sources when solving technical problems. The following lists show, in decreasing order of frequency, the sources used by U.S. and European aerospace engineers and scientists in solving technical problems.

SOURCES USED BY U.S. AEROSPACE ENGINEERS AND SCIENTISTS TO SOLVE TECHNICAL PROBLEMS

Sources	Percent of Cases
2. Informal discussions with colleagues	77
3. Discussions with experts within the organization	70
4. Discussions with supervisor	45
5. Textbooks	39
6. Technical reports	35
7. Journals & conference/meeting papers	35
8. Handbooks and standards	34
9. Government technical reports	33
10. Discussions with experts outside of the organization	25
11. Librarians/technical information specialist	14
12. Technical information sources such as on-line databases	8

SOURCES USED BY EUROPEAN AEROSPACE ENGINEERS AND SCIENTISTS TO SOLVE TECHNICAL PROBLEMS

Sources	Percent of Cases
2. Informal discussions with colleagues	97
3. Textbooks	94
4. Journals & conference/meeting papers	92
5. Technical reports	92
6. Discussions with experts within the organization	90
7. Discussions with experts outside of the organization	85
8. Librarians/technical information specialist	78
9. Discussions with supervisor	71
10. Handbooks and standards	70
11. U.S. government technical reports	43
12. Technical information sources such as on-line databases	32

With few exceptions, the U.S. aerospace engineers and scientists in the Phase 1 pilot study use, in decreasing order of frequency, the same sources that Shuchman (2) reported engineers in general use in solving technical problems. Both groups begin the process of finding a solution with what Allen (3) calls an "informal interpersonal search for information." Having utilized these sources, engineers and U.S. aerospace engineers and scientists turn to the formal literature and the assistance of librarians/technical information specialists and bibliographic tools for assistance.

Differences appear, both in terms of the use of a particular information source and the order in which the sources are used, when the responses of U.S. and European aerospace engineers and scientists are compared. European respondents prefer a greater mix of informal and formal information sources, specifically, more use of experts outside of the organization, librarians, and technical information sources such as on-line databases. Furthermore, European aerospace engineers and scientists may make greater use of technical reports and U.S. government technical reports than do U.S. aerospace engineers and scientists.

Content for an Undergraduate Course in Technical Communications

Approximately 60% of the U.S. respondents and 25% of the European respondents indicated that they had taken

a course(s) in technical communications/writing. Approximately 24% of the Americans had taken a course(s) as undergraduates, approximately 20% had taken a course(s) after graduation, and 25% had taken a course(s) both as undergraduates and after graduation. Approximately 3% of the Europeans had taken a course(s) as undergraduates, approximately 14% had taken a course(s) after graduation, and 8% had taken a course(s) both as undergraduates and after graduation. Approximately 96% of the U.S. respondents who had taken a course(s) in technical communications/writing indicated that doing so had helped them to communicate technical information. Almost all of the European respondents who had taken a course(s) in technical communications/writing indicated that doing so had helped them to communicate technical information.

European participants **only** were asked their opinion regarding the desirability of undergraduate aerospace majors' taking a course in technical communication. Approximately 70% indicated that aerospace majors should not take such a course. Of the 30% of European respondents who indicated that a technical communications course should be taken, they favored it be a required, noncredit component of the engineering curriculum.

American and European respondents were asked their opinions regarding the inclusion of 7 **principles** in an undergraduate course in technical communications for aerospace majors. The "yes" responses to the inclusion of the seven topics (principles) follow.

U.S.

Organizing information	96.5
Defining the communications purpose	90.7
Developing paragraphs	86.2
Assessing reader's needs	81.7
Choosing words	81.4
Writing sentences	80.0
Editing and revising	77.8

European

Defining the communications purpose	91.7
Assessing reader's needs	91.4
Organizing information	88.1
Choosing words	83.9
Developing paragraphs	81.7
Editing and revising	79.3
Writing sentences	66.1

American and European respondents also chose from a list of eight topics those **mechanics** to be included in an undergraduate technical communications course for aerospace engineers and scientists. The "yes" responses to the inclusion of the eight topics (mechanics) follow.

U.S.		European	
References	76.7	References	90.7
Punctuation	75.9	Symbols	81.5
Spelling	65.1	Punctuation	69.2
Capitalization	61.0	Spelling	58.8
Symbols	57.3	Abbreviations	50.0
Abbreviations	51.4	Numbers	41.3
Acronyms	49.7	Capitalization	41.2
Numbers	48.7	Acronyms	31.4

Given a list of 13 topics, U.S. and European respondents were asked to identify appropriate **on-the-job communications** to be included in an undergraduate technical communications course for aerospace engineering and science majors. Their choices follow.

U.S.

Oral presentations	95.3
Use of information sources	79.1
Memos	77.8
Technical reports	66.1
Letters	69.4
Abstracts	69.0
Instructions	57.6
Specifications	55.7
Manuals	48.3
Journal articles	46.4
Literature reviews	37.3

European

Oral presentations	98.3
Abstracts	89.3
Use of information sources	88.2
Technical reports	87.0
Instructions	76.0
Journal articles	75.9
Letters	67.3
Specifications	66.0
Literature reviews	62.7
Memos	62.5
Manuals	56.3

In an attempt to validate these findings, the top five recommended on-the-job communications were compared with the top five (on the average) technical communication products "produced" and "used" by U.S. and European aerospace engineers and scientists.

U.S.	European
Produced	
Memos	Memos
Letters	Letters
A/V materials	A/V materials
Drawings/specifications	Drawings/specifications
Speeches	Journal articles
Used	
Memos	Letters
Letters	Memos
Drawings/specifications	Journal articles
Journal articles	Conference/meeting papers
Trade/promotional literature	Abstracts
Recommended	
Oral presentations	Oral presentations
Use of information sources	Abstracts
Memos	Use of information sources
Letters	Technical reports
Abstracts	Instructions
	Journal articles

Use and Importance of Computer and Information Technology

Approximately 91% of the U.S. respondents and 86% of the European respondents use computer and information technology for preparing technical communications. Of that number, approximately 95% of the American respondents and approximately 100% of the European respondents indicated that computer and information technology had increased their ability to communicate technical information.

Aerospace engineers and scientists use a variety of software for preparing written technical communications. For the U.S. respondents, the percentage of "yes" responses ranged from a high of 94.4% for word processing software to a low of 10.8% for outliners and prompters. For the European respondents, the percentage of "yes" responses ranged from a high of 79.6% for word processing software to a low of 10.4% for business graphics.

Aerospace engineers and scientists use a variety of information technologies to communicate technical information. The percentage of "I already use it" responses range from a high of 84.3% for the Americans and 92.2% for the Europeans (FAX or TELEX) to a low of 6.1% for the Americans (laser disc/video disc/CD-ROM) and 1.7% for the Europeans (video conferencing). A list, in descending order, follows of the information technologies most frequently used. (Numbers given are percentages.)

	U.S.
FAX or TELEX	84.3
Floppy disks	74.5
Teleconferencing	58.7
Electronic databases	50.3
Electronic mail	46.6
Video tape	46.5
Desktop/electronic publishing	46.5

	European
FAX or TELEX	92.2
Video tape	47.5
Electronic databases	39.0
Motion picture film	28.8
Electronic networks	24.1
Micrographics and microforms	23.2
Computer cassette/cartridge tapes	22.4

U.S. and European aerospace engineers and scientists were asked to indicate which of those information technologies not currently being used, they might use in the future. The "don't use but may in the future" information technologies are listed below, in descending order of use. (Numbers are given in percentages.)

	U.S.
Laser disc/video disc/CD-ROM	64.9
Video conferencing	62.4
Electronic bulletin boards	53.6
Electronic networks	52.8
Micrographic and microforms	44.0
Electronic mail	43.4
Desktop/electronic publishing	41.5
Electronic databases	40.4

	European
Desktop/electronic publishing	64.4
Laser disc/video disc/CD-ROM	64.3
Video conferencing	60.0
Electronic mail	58.3
Electronic bulletin boards	56.4
Electronic networks	55.2
Electronic databases	54.2
Teleconferencing	50.8

DISCUSSION

Given the limited purposes of the pilot studies, the overall response rates, and the research designs, no claims are made regarding the extent to which the attributes of the

respondents in the studies accurately reflect the attributes of the populations being studied. A much more rigorous research design and methodology would be need before such claims could be made. Nevertheless, the findings of the studies do permit the formulation of the following general statements regarding the technical communications practices of the aerospace engineers and scientists involved in the two studies:

1. The ability to communicate technical information effectively is very important to U.S. and European aerospace engineers and scientists.
2. U.S. and European aerospace engineers and scientists in these studies spend approximately 66% and 59%, respectively, of a 40-hour work week producing and working with technical communications.
3. As U.S. and European aerospace engineers and scientists in these studies advance professionally, so too does the amount of time they spend producing and working with technical communications.
4. The U.S. and European aerospace engineers and scientists in these studies make considerable use of personal knowledge and informal discussions with colleagues in solving technical problems. However, the European respondents make greater use of the formal literature, technical reports, experts outside of the organization, and librarians.
5. Approximately 60% of the U.S. and 25% of the European aerospace engineers and scientists in these studies had taken a course(s) in technical communications/writing; approximately 100% of both groups indicated that such a course(s) had helped them communicate technical information.
6. Although the percentages vary for each item, there was considerable agreement among the U.S. and European aerospace engineers and scientists in these studies regarding the principles, mechanics, and on-the-job communications to be included in an undergraduate technical communications course for aerospace engineering and science majors.
7. Approximately 91% of the U.S. and 86% of the European aerospace engineers and scientists in these studies use computer and information technology to prepare technical communications and almost all of both groups indicated that the use of this technology increased their ability to communicate technical communications.
8. Apart from FAX or TELEX, considerable differences were reported in the information technologies used by the U.S. and European aerospace engineers and scientists in these studies.

Despite the limitations of the pilot studies, these findings contribute to our knowledge and understanding of the technical communications practices among aerospace engineers and scientists and raise questions for future study. These data reinforce some of the conventional wisdom about technical communications and question other widely held notions. The data support earlier findings by Shuchman (2) and Allen (3) and provide an updated look at the impact of computer technology on technical communications in aerospace. The findings hold significant implications for technical communicators, information managers, research and development managers, and curriculum developers and raise questions in the following areas.

If technical communications consumes approximately 66% and 58% of a 40-hour week for U.S. and European aerospace engineers and scientists, respectively, and plays a significant role in professional advancement, to what extent do aerospace engineering and science majors receive technical communications training as part of their academic preparation? U.S. and European aerospace engineers and scientists suggested the inclusion of oral presentation skills (95.3% and 98.3%), use of information sources (79.1% and 88.2%), references (76.7% and 90.7%), and organizing information (96.5% and 88.1%) in an undergraduate course in technical communications for aerospace engineering and science majors. Are these principles, mechanics, and on-the-job communications included in the technical communications courses available to undergraduate aerospace engineering and science majors?

CONCLUDING REMARKS

Worldwide, the aerospace industry is experiencing significant changes whose implications may not be well understood. Increasing cooperation and collaboration among nations will result in a more international manufacturing environment, altering the current diffusion of technology, increasing pressure on aerospace organizations to push forward with new technological developments and to take steps designed to maximize their inclusion into the research and development (R&D) process.

To remain world leaders in industry, aerospace producers must take the steps necessary to improve and maintain the professional competency of aerospace engineers and scientists and to enhance innovation and productivity as well as maximize the inclusion of recent technological developments into the R&D process. How well these objectives are met, and at what cost, depends on a variety of factors, but largely on the ability of aerospace engineers and scientists to acquire and process the results of aerospace R&D.

The ability of aerospace engineers and scientists to identify, acquire, and utilize scientific and technical information (STI) is of paramount importance to the efficiency of the R&D process. Testimony to the central role of STI in the R&D process is found in numerous studies. A number of these studies have found strong relationships between the communication of STI and technical performance at both the individual and group levels. Therefore, we concur with Fischer's (4) conclusion that the "role of scientific and technical communication is thus central to the success of the innovation process, in general, and the management of R&D activities, in particular."

In terms of empirically derived data, very little is known about the diffusion of knowledge in the aerospace industry both in terms of the channels used to communicate the ideas and the information-gathering habits and practices of the members of the social system (i.e., aerospace engineers and scientists). Most of the channel studies have been concerned with the transfer of aerospace technology to non-aerospace industries. Therefore, it is likely that an understanding of the process by which STI in the aerospace industry is communicated through certain channels over

time among the members of the social system would contribute to increasing productivity, stimulating innovation, and improving and maintaining the professional competence of aerospace engineers and scientists.

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